especially since 9/11, that becomes sacrosanct. But in fact, I believe firmly that public safety people have an even greater obligation to operate more efficiently because they get more through with less interference in a more corrupted environment which is likely to happen when you have a crisis. So there's an obligation as well -- as well as a responsibility, as well as a right for public safety people using a spectrum to use it more efficiently.

I don't want to dominate the conversation any more, but simply say that we have been very slow in adapting innovations, very, very slow. And there are lots of reasons for it, not the least of which is legacy reasons, the lawyers and the economists and all tell us about how -- what could be done and what can't be done and the reasons for it. I've read some of the papers. They're very elegantly written and they're almost convincing until you snap out of it and realize that there are other ways of looking at things.

I'm an engineer. I started my career

working on -- in the beginnings of NTSC color television. And although it doesn't show by my gray hair, it shows by my no hair.

(Laughter.)

And I started by designing color television sets, and in fact, I have an old one somewhere that still works with the signal today and has all kinds of ghosts and all kinds of bleeding of the colors and so on and one could say well, we really can't do anything because there's so much of an investment of these hundreds of millions of sets that are sitting in attics and basements and other things that are -- you can't change those things overnight. But the Commission has to find ways of making rules, if nothing else, some kind of a gradual transition to implementing new things. The thing that comes to mind that is perhaps most impressive to me as a young engineer that NTSC was a compatible system, that is to say, if you had a black and white set, you could also receive color if you had a color set, but you could also see -- and there's at least one other system

that I confess in full disclosure that I'm involved in and that is IBOC, the in-band, on-channel AM and FM broadcasting system which allows people to continue to use their crummy old analog FM and AM receivers. By the way, AM and FM radio and television are the last holdouts in the whole electronics world. So if the Commission can make sure that innovations can handle those transitions while allowing innovations to be introduced at the same time, that would be great. And I have some ideas along those lines. I'll save them for later.

MR. REPASI: Thank you, Ray. I think that your points are well taken on the differences in the services too. I think that in panel III this afternoon, we may get into a more in-depth discussion about the driving forces for some of the specific services that the Commission regulates. And broadcasting is one of those services where there might be some capabilities in other communications services that you're not able to extrapolate those same types of benefits into some of the other services. Legacy equipment is one of

those factors.

Doug, how about you? Could you offer a few comments on this subject?

MR. LOCKIE: Well, I'll go back to this never ending cycle between processing power and what it does to and for us. I look at a lot of business plans. I haven't made my investors any money yet, so in exchange I look at a lot of business plans for them. And please God, let the market go up one of these days.

At any rate, and we're seeing business plans coming through now with 1024 QAM, 2048 QAM, 10,000 PSK kinds of modems and -- sorry. That's my Palm and my phone. At any rate, your first reaction is put these guys into the loonie bins, guys and gals. And then you go through the thing and say well, they're just taking digital processing and we've got all this process capability going on in general purpose computers, but if you go in and do a pipeline computer based on say maybe an FPGA, you can take 10 instruments and stick them into the knob of the instrument and

by the time you click from one channel to the other on say a spectrum analyzer or a network analyzer or a bit-error rate tester, you've loaded a new program into this FPGA and it's become a pipeline process that maybe has a 100 to 1,000 times more processing power than the previous general purpose computer there. Where does it all stop? But the interesting things that these modem companies are doing is that okay, we can't build the oscillator that's clean enough to support 10,000 PSK and the digital processing guy says that's okay. I'll equalize out the noise in your oscillator. You just give me 2/10ths of a nanosecond delay which maybe is an antenna that's spaced that far apart and the signal coming in, I'll listen to what the oscillator is doing buried down there in the data stream and I'll equalize out the noise in the oscillators. Now you use a crummy old dirty oscillator and still have your 10,000 PSK. Maybe. And they'll do the same things in the nonlinearities in both propagation path and in the amplifier generating the signal. So there's all

that stuff coming along. Well, as that's coming along, you could be building that into variable rate modems that adjust to whatever the spectrum is doing, whatever the noise environment is doing. One interesting thing though and I want to point this out to the FCC, you guys have got a lot -- guys and gals -- have got a lot of power out here and maybe once in a while you need to practice a little tough love. Now with this -- and I'll use broadcasting as probably the largest number, what have we got? Several hundred million TV sets in America and one of the little things that hangs us up on going forward is the factories that are there to design the analog front end. It's a discrete thing and it costs $10 or $11, but it's still an analog front end. It's remarkable what the factories in Taiwan and Thailand, wherever, do to automate or not automate the front end of a TV set, but we've still got a front end on a TV set that's this big by this big by this big and it's got 80 analog discrete components, filters, passers and stuff. It could be a chip the size of the tip of

your pen. And probably will be in a few years. And so one of the things the FCC could be doing is saying, 5 years from now, 8 years from now we're going to be with a digital front end that has all these capabilities in it in terms of interference mitigation and you've got 5 or 6 or 8 years to do it and if you haven't done it by then, we're going to audit your taxes or something.

(Laughter.)

There's a lot of ways that you can incite and incent people to go out and work on these things, but -- well, so there's a lot of other things you can do in the analog world as well, but never to downplay, gee, when you buy your TV set you also, you also buy a cellular and a wi-fi and an ultra-wide band and the capability is there to make this stuff to go off and happen and it will happen over a period of time, but there's probably a lot we can do to skootch it along faster, with some gentle suggestion and rules.

MR. REPASI: Your gentle suggestions are well taken.

Dale, how about you?

MR. HATFIELD: I'll be very brief. I would again, as I did in the last panel distinguish between the situation where the improvements benefit the licensee, like in cellular where if I'm more efficient, I can put in more subscribers and make more money. In a situation where we have, for example, in television where that control is not exercised, and I think there particularly, the advice that the prior two panelists gave, the Commission being a little bit more aggressive is probably well taken. I'm -- here again, people have heard me say this so many times, but I'm going to say it again is in 1977, something like that, when was it? We had an RF monolithic study and it showed that if the Commission at that time had stepped in and just tightened up the selectivity a little bit on television sets, we would not have the problem we've had today. In fact, we could keep the analog, we could recover, we could recover that spectrum, had the Commission stepped up to it. Now I'm not saying whether at the time that was a

good or bad decision because you multiply a couple of bucks times the millions of television sets that have been made here, that is real money. But it illustrates, I think, it illustrates where the Government could, especially where the benefits don't accrue to the licensee, could step in and have some real strong benefits. I'll just repeat, we wouldn't be having the difficulties we have today over that price spectrum if the Commission had gone ahead.

I'm not attacking anybody, I was actually here at the time at the Commission during part of that and there was pressure, receiver manufacturers didn't want the extra costs. There were problems with the Communications Act, did we have jurisdiction, the ability to require receiver specs. But I'm just reinforcing what I heard. I think the Commission can, without intruding too much in the marketplace, have a real positive benefit here in terms of recovering spectrum that we so desperately need.

MR. REPASI: Thank you, Dale. I think

that one of the purposes of these workshops and the Spectrum Policy Task Force in general is to have guidance available to us at the Commission so that any decisions we make today are the best decisions we can make that will be still relevant 10, 20 years from now and still working fine.

Why don't we go to the other end of the table and start with -- and begin, continue on with Jack Wengryniuk on what his views are from the satellite perspective, what is done on the satellite side as far as dealing with the interference environment or the operating environment when new applications, for instance, are -- you want to deliver new applications to the public, what do you have to go through on the satellite system operator to adjust to the new environment.

MR. WENGRYNIUK: Well, you also asked about the, sort of the equalizing of power, the interference environment and what has happened in that regard.

Satellite systems by their very nature,

are spraying down power from space and so you're getting more or less a uniform distribution of power across the surface of the earth which is from a satellite sharing with satellite perspective is a good thing, because you don't have the kind of hot spots that you might have in the terrestrial world.

The transition from analog to digital communications, the virtually wholesale transition from the old TVFM or FTMFM types of signals which had highly variable power spectral densities, as you were to scan across the spectrum, to the digital world where you have a more or less uniform distribution of power, even for different bandwidth carriers because it automatically scales the power to the energy per bit, has helped to sort of again normalize the interference environment amongst systems and within systems, the intra-system interference as well. The types of advances that I spoke of earlier in the satellite world with high levels of frequency re-use, dual polarization, etcetera, have increased the levels of intra-system interference that the satellite network provider

has to deal with.

One of the difficulties that we see certainly in the satellite world with the introduction of new services and part of this is driven by the advances in digital communications as well, or the digital processing power is you take a signal and you encode it as much as you possibly can so that it uses as few bits as possible to transmit the communications channel or as small bandwidth as possible. The problem with that is is that system now becomes highly susceptible to errors because you have a lot of interdependency from one bit to another because you're taking advantage of the redundancy and the signal that you're encoding. And so whereas for a voice signal, you may be able to tolerate to talk in technical terms, bit error rates of 10^{-3}. For a video highly encoded video transmission, you may require 10^{-6}, 10^{-7} bit error rate. So you become much more susceptible to interference of the same types of things that you're doing to improve your spectral efficiency and in some cases reduce the

amount of interference you may cause to yourself, also make you more susceptible to interference. So there's this balancing act that's continually at play and of course, all of this is happening on top of or beneath the desire of the satellite provider to provide as much service as possible to the public as low a cost as possible and of course, to make as much money as possible. So it's this balancing act of all of these sort of competing forces in trying to find out what is the best point at which to strike that balance in the provision of service.

MR. REPASI: Thank you, Jack. Yes one of the tradeoffs, I think in the design of satellite systems too is there's only so much energy you can soak up from the sun. And the trade offs are between power and bandwidth. We're going to higher orders of modulation or error correction and so forth. That all requires more power or more bandwidth. You've got some tough choices, I think, in that type of environment.

Jack Rosa, from a software defined

radio standpoint, what do you see kind of being the next step in what SDRs would be able to offer as far as playing a role in system, communication system design as far as mitigating or eliminating interference to improve performance?

MR. ROSA: As I said before, the capabilities are there to solve many of these issues. What I heard several times, in fact, was that we are slow to adopt. We are slow to progress and so forth. And in some cases some people believe that wave form complexity is beginning to out pace Moore's law, so we need the next step and the next generations of technology to get there.

To get to the bottom line, I think the most significant thing the FCC can do is to become a proactive player in advancing the course. Business models will take care of themselves. It's interesting. To pick up where Jack left off, is that in satellite communications you pay for bandwidth. You pay for power, okay? And people -- you optimize those tools. You get the right amount of power and bandwidth, so you don't pay any more

than you need to. And then you try to get the best you can out of that, what you just paid for.

So the economic factor draws that equation, that is, if I can get all the bandwidth I want, why do people want to go from digital analog radio. I don't like the digital TV system, because now you can get three or four in one transponder rather than have just one transponder being in your life. So there's lots of opportunity here to move forward. Those are just modest -- those are what you call the no brainers. We knew how to do that years ago. But there's a lot more to be gained, significantly more to be gained and so even in spite of the attempts of Mr. Gates and Cisco to push this to the edge which is the opportunity, I believe the potential, the technology that exists today or is being developed today to deal with every one of these problems. Spectral management. If you had a fast enough machine you could monitor the spectrum continuously. You could put in intelligent controllers, so-called bandwidth on demand. That technology can be accomplished now.

From every aspect, from adaptive antennas to -- the technology exists to solve all these riddles. And it's -- I think the role FCC can play again is to do -- take actions proactive actions, be proactive and try to support the development of these technologies. The economic gains will come later.

In addition to that, you should consider and maybe I'm jumping ahead to the next activity which is incentivize people to do it. It's not going to happen naturally and when there's economic gains to be made you can do it.

I had some slides I wanted to show. For instance, it is possible, for instance, to take transmitters and almost totally purify them, directly at RF. It's possible to build correlation-based maximum like modulators, okay? The optimum filter, the textbook -- it's possible to build spectrally pure carriers, okay? All these techniques are available, but it's all invested in the next generation technology.

Software-defined radio will give you

the maximum flexibility where wave forms are defined by numbers. It's not quite -- Defense is moving in that direction, but it's not quite down to just punch a number in. But if you know what the template is of the wave form, and very complex wave forms too, by the way, they're dealing with 30 wave forms, some of which are incredibly complex, hopping inside of half inch bandwidth is not a piece of cake. But it's possible to do it. Very possible. In fact, it's do-able. We know it's do-able.

But somebody has to advance the cause. In that case, you have a monolithic structure. It is now, at least. They formed the Joint Office to make this happen. They're going to spend several billion dollars to prove they can do it, okay? There is no corresponding monolithic situation, I think in other areas, there's a semblance of it. Maybe FCC can be the driving force that puts that together and it becomes a monolithic force that makes it happen.

MR. REPASI: Thank you very much, Jack.

One of the things that we haven't touched on in this panel and I don't expect to is the -- whether or not complexity, system complexity equals costs. I mean we take something from a Defense-oriented -- when you take something that billions of dollars have been invested into the research and development of software defined radio, for example, but you take that to the commercial side, that, I think is a pretty difficult transition, something that we'll be facing at the Commission as well.

At this point, I'd like to open up the panel to the public for comments if they have any comments or questions for the panel here.

Yes sir, in the back.

MR. STEVENSON: Thank you, Carl Stevenson. I'm with IEEE 802.18 and I work Gear Systems. I'd just like to echo what Mr. Lockie was talking about before in terms of reducing interference and even improving spectrum efficiency by sort of holding incumbents feet to the fire a little bit in terms of keeping up with technology. As it goes right now and the example of

television, with NTSC was a prime example. There's been many, many years where you've had a legacy system that's essentially been protected from needing to make any progress towards more efficient use of the spectrum just because of the fact it was there.

I'd also like to comment on what Mr. Hatfield said earlier in terms of starting to lean towards receiver standards. Receiver standards, at a minimum, give you the ability to figure out what you have to protect against in terms of being able to share spectrum with incumbent users. And while I don't believe that legacy receivers should receive indefinite protection against anything new that may come along, I recognize the fact that you can't force the issue too rapidly. The transition can't be draconian. It has to take into account reasonable equipment life cycles and so forth. But you also need to recognize that the upgrades to new technology will also provide benefits to the users that are required to keep up with the times.

Thank you.

MR. REPASI: Thank you. Questions?

DR. KOLODZY: Paul Kolodzy. I have a question for the panel that you might be able to address since this is technology. You have possibly two ways to look at interference. One is technology in which to avoid interference and the other one is technology to mitigate interference or to deal with it, to handle it within your systems. What I don't understand, I hope the panel can comment on is number one, is which way, where is technology really leading us and where would you see our first sets of advantages or advances that could actually help in the area of interference? Should we be putting more emphasis toward trying to avoid it or should we be putting more emphasis on how to mitigate it?

MR. REPASI: Anybody want to answer that?

DR. PICKHOLTZ: I think the answer is both. It depends on the circumstances. Some of the comments I made about the new technologies that are there to not only mitigate it, but possibly

eliminate it, apply primarily to those situations we are operating a common shared spectrum in a multi-user environment so that you know something about the nature of the interference you're trying to either eliminate, avoid, mitigate, use, what have you. There are other circumstances where the only thing you can hope to do in a short period of time is to minimize the amount of interference that's generated. That's the traditional point of view, putting masks on transmitters and things like that. But even those in principle, the first one, the first category is not in principle. The first category is something that we can actually implement today and people are implementing it. And the bottom line is, in fact, economics. You don't implement it because -- they're not implementing it because there's some FCC edict that's telling them they've got to do this in order to operate more efficiently. Since their revenue stream is dependent on having a spectrally efficient system, they actually get more for what they have or what they've purchased in the event of

an auction. So some of the most sophisticated techniques that are yet to be seen in the environment of the general economy, are fairly imminent. That is, those systems that operate in a multi-user environment. And I might add, although I mentioned satellite -- cellular -- I think satellites might fall into a similar category because you can have interference sharing between spot beams and similar things. It's essentially the same idea.

So the question then leads to what could be done, what kind of techniques. I had a bunch of slides, but I'm not going to do that. There is a body of techniques that are ready and waiting that are well within the capabilities of the current technology to exploit. In some instances, perhaps mostly in legacy systems where there's no incentive to exploit them it's going to take a while unless there's a push by the Commission to do it.

But the bottom line question is, and I'd like to take this up because I think there's a

need to say it, of what the Commission can do in a larger sense and I think it depends very much on the nature of the services that are being used. For example, I personally think that the Commission ought to expand the unlicensed bands and there are plenty of places I can tell you where there's a lot of wastage, because the unlicensed band has a nice, neat idea of -- it's a Darwinian system which it's almost like the invisible hand of Adam's where the survival of the fittest encourages people to use the most advanced technology to not only exploit the most that they can get for themselves, but to avoid the deleterious effects of the other people using the spectrum. And I would like to see more of that. There's, of course, a lot of people around who would not like to see that, but I think that there's a lot of merit to that.

I also think that the Commission can press those users who up until now have had no real economic or other incentive to improve, to share the burden of making themselves more spectrally efficient. And by the way, most spectrally

efficient does not automatically imply, as I sort of heard a sense of that, not only imply a degradation of performance. If you compress signals and then properly encode them, you're going to get both a reduction in the amount of bandwidth that you use or another way of putting it a larger spectral efficiency and at the same time get a greater performance value as measured by any measure you want, frame error rate, bit error rate or other means, subjective or otherwise.

And there are certain things that are different like broadcasting. I have already mentioned NTSC. There's got to be a little bit harder push on the part of the Commission to speed up digital broadcasting and by that I mean things that are already in place like digital television, HGTV, but also radio broadcasting which is already started with XM and Sirius, but soon, hopefully, IBOC, which is right in the current radio spectrum.

And then finally, the thing that will make it possible, and this is very controversial, maybe the next President or the current President

should appoint as the next Commissioner an engineer on the Commission.

(Laughter.)

MR. REPASI: Thank you, Ray.

(Laughter.)

MR. REPASI: I think we would agree on the panel that -- not about the next appointment of a Commissioner --

(Laughter.)

-- but agree that dealing with interference and the interference environment is a two-sided process, one you want to mitigate it from the transmitter standpoint, do what you can to make your system as clean as possible so that other users in your band and other users adjacent to your frequency band aren't impacted by your operations. But at the same time, you want to look at what can be done on the other side of the system to figure out what can be done on the reception side to avoid receiving interference from other users in the same spectrum and other users in the adjacent spectrum and I think that's one topic in segment III that